Influence of Gender Performance Stereotype on the Error-Related Negativity and Error Positivity

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Introduction

- Following a mistake, people commonly display two event-related potential (ERP) components generated by the anterior cingulate cortex: **error-related negativity (ERN),** a negativity peaking 0-100 ms after the mistake, and **error positivity (Pe)** peaking 150-350 ms after
- The ERN and Pe may reflect the motivational and emotional impact of errors
- ERN is associated with more subconscious awareness of errors and Pe with more conscious awareness
- Trait anxiety positively correlates with ERN amplitude
- Under gender stereotype threat, women perform worse on some tasks and experience greater levels of anxiety
- We hypothesized that women exposed to **gender stereotype threat (ST)** will show **larger** ERN and Pe amplitudes than those **not exposed to stereotype threat (NST)**

Method

Participants & Groups:

- 31 female UWEC students (age 18-25): 14 in ST group, 17 in NST group; 4 excluded from EEG data analysis due to EEG noise (11 ST, 16 NST)
- Stereotype threat: extra language given verbally before starting task: *"Previous research has shown that women perform worse than men on this task. Our purpose is to see whether this holds true for UWEC students and whether that's reflected not only in behavioral performance but in brain responses as well."* (No such difference actually reported in the literature)

Measures (* anxiety-related):

- Bem Sex Role Inventory (BSRI)
- Social Identities and Attitudes Scale (SIAS)
- State-Trait Inventory for Cognitive and Somatic Inventory (STICSA)*
- Penn State Worry Questionnaire (PSWQ)*
- Cognitive Test Anxiety Scale (CTAS)*
- Follow-up questions regarding task (e.g., how much bothered by mistakes made)

Flanker task paradigm:

- Participants seated 63 cm from the monitor
- 12 blocks of 48 trials each, each trial showing a string of 5 curly braces (stimulus duration = 200 ms each, but the central brace did not appear until the last 50 ms) with 2000 ms between trials
- Participants pressed a key corresponding to direction of central curly brace
- Each string was either congruent }}}}} , {{{{{ or incongruent }}{}} , {{}{{
- Following each block, if accuracy > 90%, response speed emphasized; if accuracy < 75%, response accuracy emphasized

Electrophysiology:

- 64-electrode GSN (Electrical Geodesics Inc.)
- 250 Hz sampling; 0.1 to 30 Hz bandpass filter
- Vertex reference; re-referenced to average
- ERN: mean amplitude at FCz calculated over a 20 ms window centered on peak amplitude 0-100 ms after response (**Figure 1)**
- Pe: mean amplitude at Fz, Cz, and Pz calculated over a 150-350 ms window after response (**Figure 1**)

Results

	No ST		ST		
	M	*SD*	*M*	*SD*	*p*
Reaction Time (milliseconds)	282.72	(30.07)	283.20	(32.33)	0.97
Accuracy (proportion)	0.90	(0.06)	0.91	(0.04)	0.53
CTAS	64.59	(13.97)	64.57	(12.30)	1.00
PSWQ	49.59	(9.35)	50.00	(8.50)	0.90
STICSA	38.35	(10.07)	37.36	(12.08)	0.80
BSRI-Femininity	4.95	(0.64)	5.09	(0.55)	0.52
BSRI-Masculinity	4.52	(0.63)	4.64	(0.78)	0.62
SIAS-Math Identification	25.53	(11.05)	26.00	(9.09)	0.90
SIAS-Ethnic Identification	15.65	(5.18)	15.29	(4.83)	0.84
SIAS-Gender Identification	14.41	(5.10)	14.71	(5.77)	0.88
SIAS-Gender Stigma Conscious	22.00	(5.88)	23.79	(7.89)	0.48
SIAS-Ethnic Stigma Conscious	15.38	(5.16)	15.36	(6.59)	0.99
SIAS-Negative Affect	25.41	(7.31)	24.86	(5.75)	0.82
Attitude towards Mistakes	3.53	(0.51)	3.57	(0.51)	0.82

Table 1: Behavioral and scale measures between groups.

- ERN. 2 x 2 ANOVA: Response (Incorrect vs Correct) x Group (ST vs NST)
- Pe. 2 x 3 ANOVA: Response x Group x Electrode (Fz, Cz, Pz)
- Larger ERN for incorrect responses (M = -4.56, SD = 3.57) than correct responses (M = -1.60, SD = 1.08, $p < 0.001$) (Fig. 1)
- Larger Pe for incorrect responses (M = 1.47, SD = 1.43) than correct responses (M = -1.25, SD = 1.10, $p < 0.001$) (Fig. 1)
- No significant ERN difference between ST (M =-4.05, SD = 2.31) and NST (M =-4.91, SD = 4.26) groups (Fig. 2)
- For Pe, significant Response x Group interaction (F (1, 25) = 8.11, p = .009, η_p^2 = .25) , and Response x Electrode interaction (F (1.43, 35.72) = 74.79, $p < .001$, η_p^2 = .75, Greenhouse-Geisser correction)
- Conducting separate ANOVAs for each electrode, Response x Group interaction was significant only for electrode Fz (F (1, 25) = 9.13, p = .006, η_p^2 = .27), not for electrode Cz or Pz (F < 1) (Fig. 2)**.**
- For electrode Fz, Pe (following incorrect responses) was "more positive" in the NST group (M = -0.04, SD = 2.51) than the ST group (M = -3.53, SD = 2.45, p = .001) (Fig. 2)**.**
- No significant group difference on performance or scale measures (Table 1).

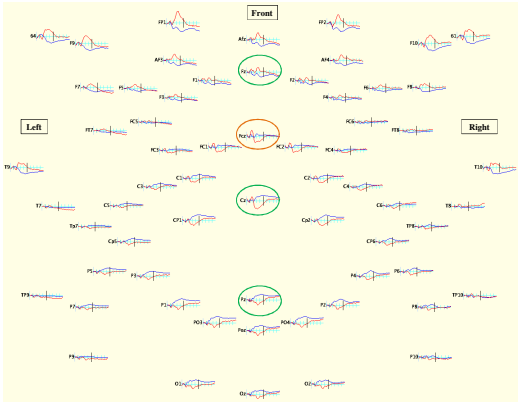

Figure 1: ERPs time-locked to **Incorrect** and **Correct** responses, grand averaged across all subjects (both ST and NST). ERN scored at electrode FCz (orange oval), Pe at electrodes Fz, Cz, Pz (green ovals).

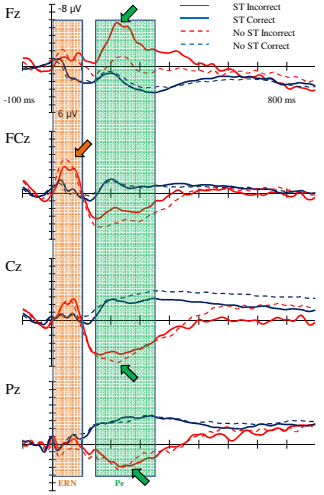

Figure 2: Grand averaged waveforms for both groups at relevant electrodes. ERN is observed during 0-100 ms window, Pe observed during 150-350 ms window.

Discussion

- The groups differed for Pe but not the ERN; gender stereotype threat may have more influence on aspects of error processing associated with conscious awareness (although note no stereotype threat impact on subjective report of how much participants were bothered by their errors).
- But what kind of influence? At more posterior sites (Cz, Pz) the Pe was not significantly different between groups. The Pe looks "more positive" for the NST than ST group at site Fz, but in the ST group it doesn't just look less positive; it looks like a bigger *negative* deflection! Two main possibilities:

1: More positive is more positive. The Pe is larger in the NST group, against prediction. Stereotype threat may reduce participants' performance expectations, making mistakes less impactful

2: The Pe peaks in the negative direction at Fz because the dipole (see our other poster for info on this) lies somewhere below and between sites Fz and FCz; what matters is the *magnitude* of the deflection, not the *direction*. So at Fz the Pe is actually larger in the ST group. As predicted, stereotype threat may have increased participant concern with errors, making mistakes more impactful.